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Reynolds Number in MAGCOOL Subcooler

K. C. Wu

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ABSTRACT

A workshop on Ultra-High Reynolds Number Flows was held at Brookhaven National Laboratory on June 18-20, 1996. One of the papers presented in the workshop concerns with helium flowing through an object in a apparatus similar to the SUBCOOLER used for testing SSC magnets in the MAGCOOL facility a few years ago. The Reynolds Number for helium flow in MAGCOOL SUBCOOLER through a 4 cm diameter pipe was investigated for potential high Reynolds number study. Typical Reynolds number of a few million can be obtained easily. To achieve Reynolds number in the order to 100 million, superfluid helium must be used.

MAGCOOL SUBCOOLER

Originally designed for testing SSC magnets, the MAGCOOL SUBCOOLER[1] incorporates three major features: 1) a circulating compressor for closed loop circulation of 100 to 150 g/s single phase helium at 5 atm, 2) a cold vacuum pump for adjusting operating temperature between 4.35 and 3.5 K and 3) a wet expander to balance the compression work of the cold vacuum compressor.

The MAGCOOL SUBCOOLER has been operated reliably for approximately 10,000 hours. The lowest temperature obtained in the helium pot inside the SUBCOOLER is 3 K. Depending on the head rise, circulation of 800 to 1400 cc/s of supercritical helium has been achieved. The SUBCOOLER was shut down in 1993. The unit as well as its instrumentation and controllers is well kept at working condition. Test pieces can be connected to the SUBCOOLER through bayonets.

REYNOLDS NUMBER

The Reynolds number for pressure 3 to 15 atm and temperatures 3.25, 4 and 5K have been calculated. As shown in Table 1, typical Reynolds numbers are in the neighborhood of one million. In Table 1, a volume flow of 1000 cc per sec (one liter per second) is assumed. The highest Reynolds number is 1.2 million at 3 atm and 5 K. Decrease the test pipe diameter to 2 cm will increase the Reynolds number to 2 million. Slightly higher Reynolds number can be achieved by increasing the speed of the circulator. However it is rather difficult to have the Reynolds number greater than 10 million.

Table 1 Reynolds number in MAGCOOL SUBCOOLER

Pressure atm	Temp-erature K	Density g/cc	Viscosity g/cm-s	Kinematic Viscosity cm^2/s	Volume flow cc/s	Pipe Diameter cm	Velocity cm/s	Pipe Re number
3	3.25	0.146	4.19E-05	0.0002870	1000	4	79.6	1109147
3	4	0.138	0.000038	0.0002754	1000	4	79.6	1155967
3	5	0.117	0.000031	0.0002650	1000	4	79.6	1201363
5	3.25	0.150	4.59E-05	0.0003060	1000	4	79.6	1040228
5	4	0.144	4.19E-05	0.0002910	1000	4	79.6	1093953
5	5	0.129	3.58E-05	0.0002775	1000	4	79.6	1146983
10	3.25	0.158	5.52E-05	0.0003494	1000	4	79.6	911104
10	4	0.153	5.04E-05	0.0003294	1000	4	79.6	966298
10	5	0.144	0.000044	0.0003056	1000	4	79.6	1041741
15	3.25	0.164	6.42E-05	0.0003915	1000	4	79.6	813128
15	4	0.160	5.83E-05	0.0003644	1000	4	79.6	873578
15	5	0.152	0.000051	0.0003355	1000	4	79.6	948688

SUMMARY

Force flow type experiments can be performed in the MAGCOOL SUBCOOLER for Reynolds number up to a few million. Higher Reynolds number maybe possible with some modifications of the system.

REFERENCES

1. K. C. Wu, etc. " SUBCOOLER ASSEMBLY FOR SSC SINGLE MAGNET TEST PROGRAM", Advances in Cryogenic Engineering, Vol 37A, p763, Plenum Press, New York, 1992